Improved Blast Capacity of Pre-engineered Metal Buildings using Coupled CFD and FEA Modeling

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Abstract

The initial CCPS guideline [CCPS, 1996] for estimating lethality for building occupants within petrochemical buildings subjected to blast hazards was based on building construction type and peak overpressure. This method allows for a quick screening of building occupant vulnerability but does not include the effects of the duration of the blast that the buildings are subjected to. Blast hazards within petrochemical facilities include vapor cloud explosions (VCE), BLEVEs, and bursting pressure vessels. VCE’s include both deflagrations having long blast durations and detonations having much shorter durations. Bursting pressure vessels can also be characterized as having relatively short durations. Therefore, the latest CCPS guideline [CCPS, 2012] removed this singular peak overpressure methodology and provided occupant vulnerability as a function of building damage and construction type as a function of peak overpressure and duration. Unfortunately, this improved method on blast characterization did not provide a way to correlate blast loading with building damage.

This blast-to-damage correlation is required to conduct quantitative risk assessments. A range of simplified tools are available for assessing the response of structural components and building construction types to blast loads. These tools include Single Degree of Freedom (SDOF) models and Pressure-Impulse (P-I) iso-damage charts. These simplified tools generally do not account for the complex response and failure of real structures or the difference in response to different forms of blast loading that include finite rise times (blast waves). Iso-damage charts may be based upon historical data gathered from a range of sources and are often based upon blast damage caused by High Explosive (HE) detonations.

This presentation illustrates the use of multi-degree of freedom structural systems for a pre-engineered metal building (PEMB). PEMBs represent the majority of building construction within petrochemical facilities. Computational Structural Dynamic (CSD) finite element analysis (FEA) and Computational Fluid Dynamic (CFD) approaches are used to show the level of conservatism
in estimating the blast capacity of PEMBs compared to more traditional SDOF methods. Fully coupled CFD and FEA modeling that includes the beneficial effect of including the air that is internal to the building is demonstrated.

**Key Words**

Petrochemical facility siting, VCE, CSD, CFD, FEA, blast pressure and impulse, blast waveform, PEMB